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EVALUATION OF THE PAYBACK FOR THE SOLAR DHW SYSTEM AT CRAIGWIEL GARDENS APARTMENTS

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LONDON, ONTARIO

EVALUATION OF THE PAYBACK FOR THE SOLAR DHW SYSTEM AT CRAIGWIEL GARDENS APARTMENTS

Introduction

Solcan Ltd has designed and installed a solar hot water system on the Craigwiel Gardens Senior Citizens Apartments in Ailsa Craig, Ontario. There are 47 apartments in the one floor building, with approximately 50 occupants in total. The solar water heating system was designed to supplement the building's domestic hot water requirements which are normally supplied by electricity. The solar system incorporates 16 Solcan 3001L collectors (see Figure 1), comprising an area of 35.2 square metres, with a storage capacity of 820 litres.

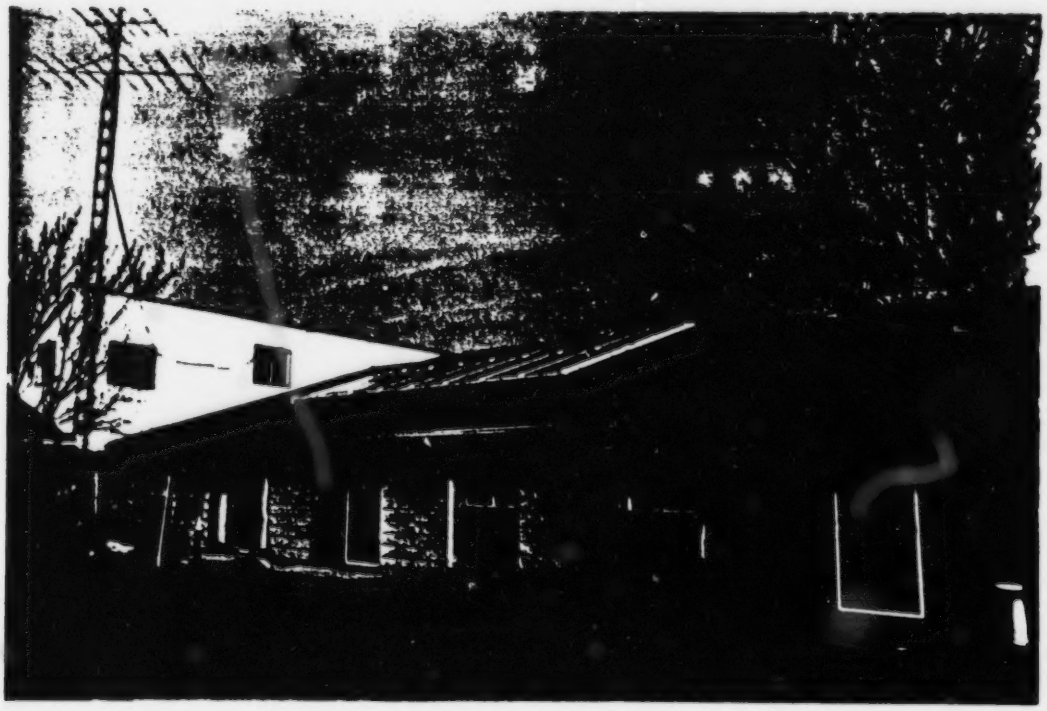


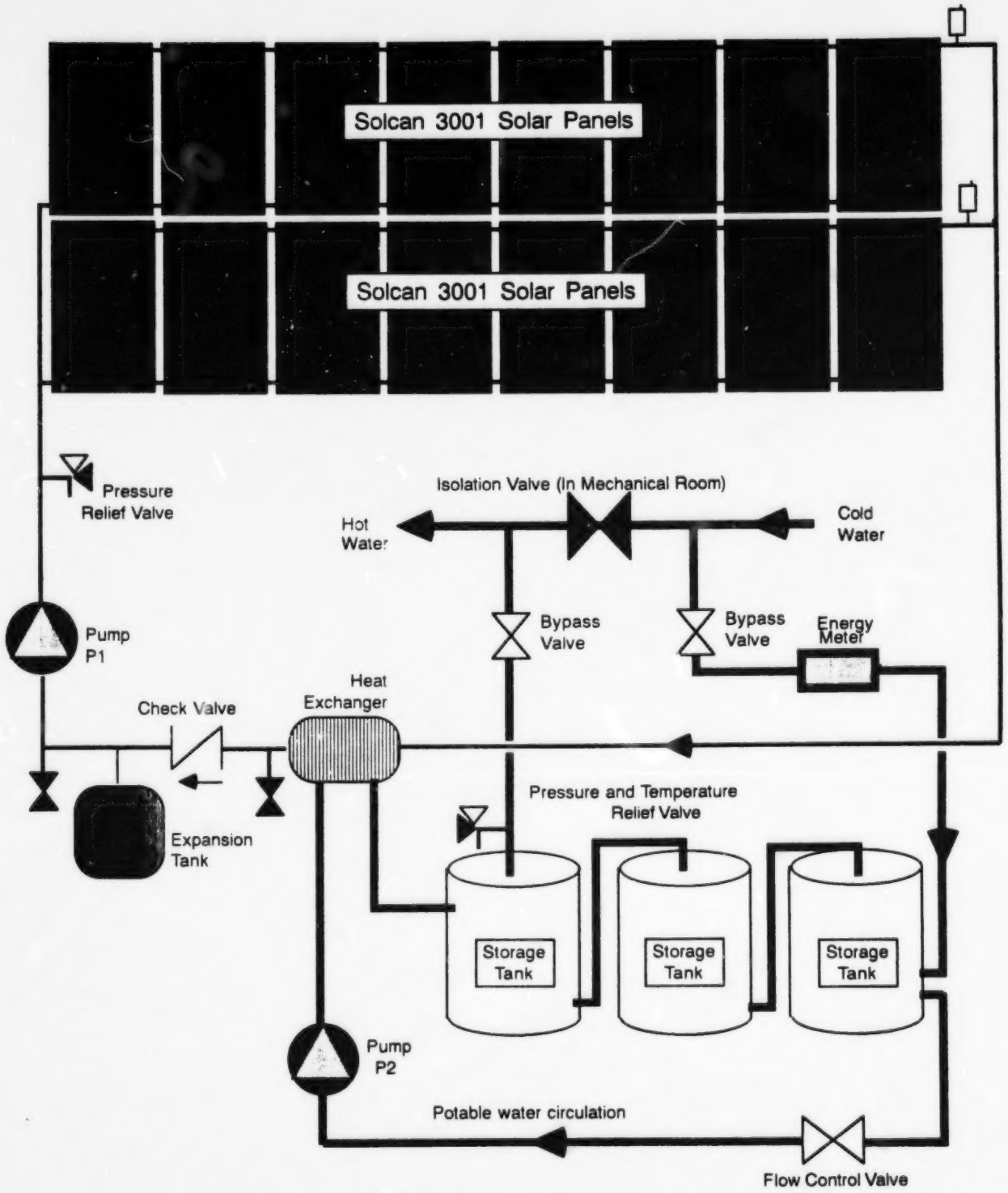
FIGURE 1

The system consists of a solar loop circulating antifreeze between the solar collectors and a heat exchanger, and a potable water loop circulating water between the heat exchanger and the storage tanks. (see Figure 2). To protect against freezing, the solar loop contains a non-toxic food grade propylene glycol/water mixture.

A temperature sensor is positioned at the top of one solar collector and another sensor is at the bottom of a solar storage tank. An electronic differential controller compares the temperatures and energizes the pumps whenever there is enough useful energy from the sun i.e. when the collector temperature is 8°C hotter than the water in the solar storage tank. Pump P1 then circulates the water/antifreeze mixture up to the collectors and back through the heat exchanger. The domestic water is heated by circulating potable water (Pump P2) through the heat exchanger and back to the solar storage tank. The heat collected in the solar storage tanks is passed to the conventional hot water storage tanks whenever hot water is a drawn from the system. If the water from the solar storage tanks is below the desired temperature, the electrical water heaters will boost the temperature up to the set point. The system operates entirely automatically. When the temperature difference between the collectors and the storage tanks drops to less than 3°C as sensed by the differential controller, the pump is de-energized and the system shuts off.

An energy meter (model SVME) on the incoming cold water line monitors the hot water consumption as well as the temperatures in and out of the solar hot water storage tanks. It reads out in GJ of energy and volume in litres; it measures energy by integrating the flow and the temperature differnce between in and out.

Figure 2



CRAIGWIEL GARDENS

Solar System Schematic

Evaluation of Performance

The expected hot water load was calculated using the ASHRAE 1980 Systems Handbook (p 37.13) as follows: 155 litres/apartment/day x 47 apartments = 7,290 litres/day, which works out to 2,660,000 litres/year. This method gives average day values (151.6 to 159.2 litres/day) and maximum day values (276.7 to 303.2 litres/day) for apartments. The anticipated thermal performance of the solar system was evaluated using WATSUN. The predicted solar gain based on the calculated hot water load was 94.5 GJ/year. Monthly readings from the energy meter for 1987 were plotted in Figure 3 and show significantly greater solar contribution in the summer months. The total solar contribution for the year was 48 GJ.

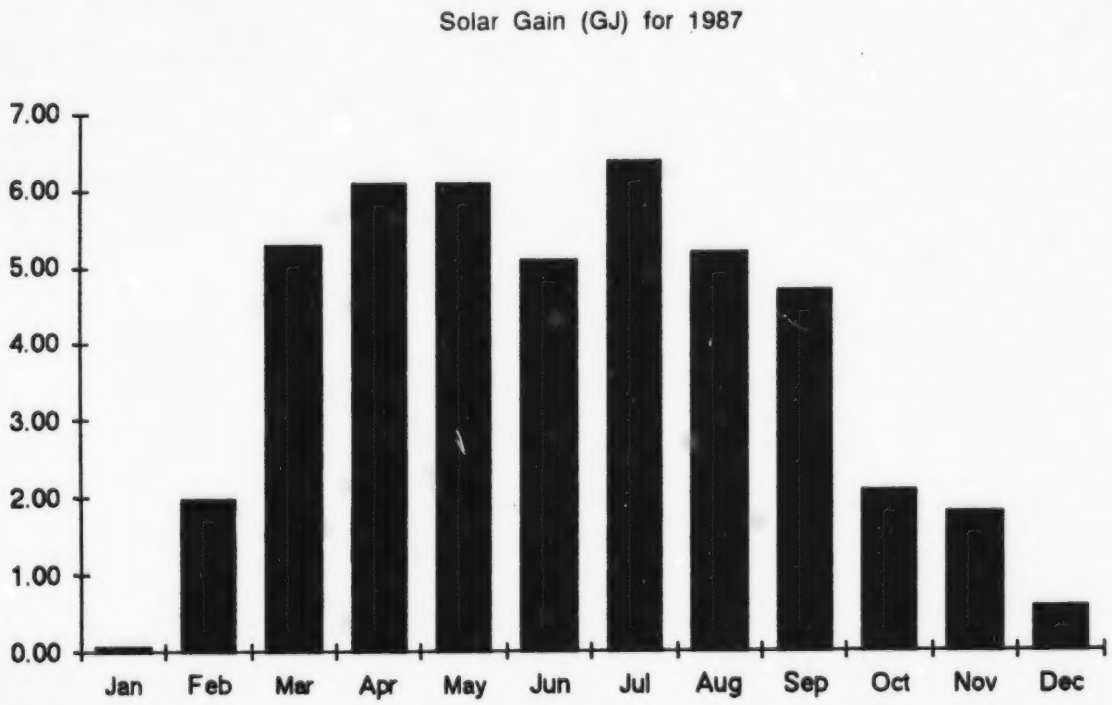


FIGURE 3

From the time the system was commissioned on 27 February 1986 until 26 February 1987 the solar energy gain was 46.30 GJ and by 7 March 1988 was another 48.57 GJ. The water and electricity consumption from April 1985 to March 1986 according to the PUC bills which are included in Table 1 on page 6 were 1,020,000 litres and 572,000 kWh (.561 kWh/litre); for the period April 1986 to March 1987, which includes the start-up, the water use was 996,000 litres and electricity use was 552,000 kWh (.554 kWh/litre); and for the period April 1987 to March 1988 water was 1,060,000 litres and electricity was 526,500 kWh (.497 kWh/litre). This represents all the water used, cold as well as hot, and all the electricity, for cooking and lights as well as heating the hot water.

Figure 4 shows water consumption (readings every two months) and electricity usage (every month) plotted from the PUC bills against time for three consecutive years; the first without the solar system and the other two following the solar installation. There was significantly more energy used in 1986 than in 1985 with a slight reduction in 1987, and significantly more water used in 1987 than in 1986. Even so, the actual total amount of water used was significantly less than the hot water usage alone as predicted using the ASHRAE Handbook which resulted in an energy prediction twice as large as the actual amount used.

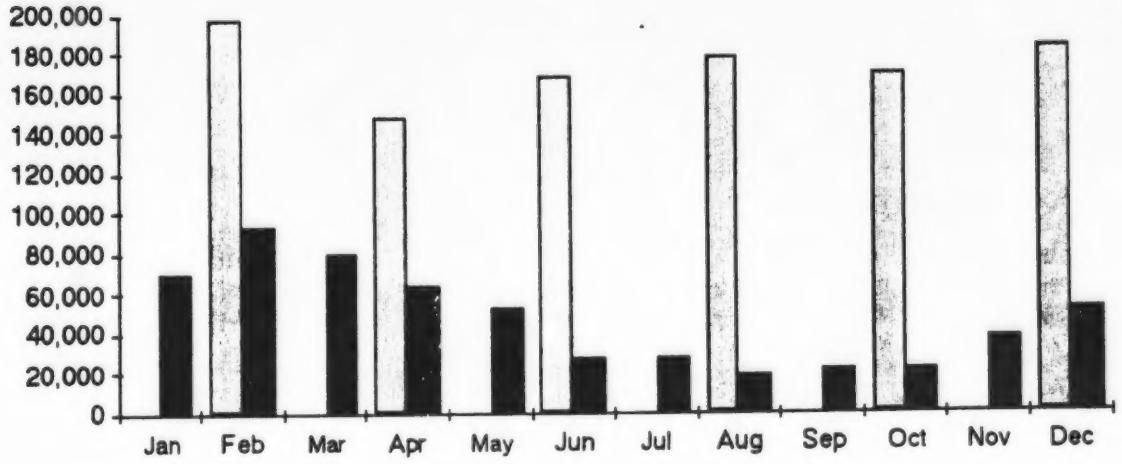
A recent discussion with the Supervisor at Craigwiel Gardens suggested that the estimate of hot water usage (155 litres/day) was much too high for the occupants of that facility. They grew up in an era when it was common to wash the dishes once a day, wash the clothes once a week and have a bath every Saturday.

The energy meter incorporates a flow totalizer. It started at zero on 27 February 1986 and read 1,713.6 m^3 or 1,700,000 litres on 8 March 1988 which is an average of 856,000 litres of hot water per year for two years. The meter read 1120.0 on 26 June 1987 which represents 592.7 m^3 in eight months or extrapolated over a year gives 889,050 litres in a year which is in line with the total over two years. The total water flow to the apartments, according to the readings from the PUC bills, represents hot as well as cold water. This means that approximately 80% of the total water consumption is used as hot water i.e. 850,000 litres of hot water /1,071,000 litres

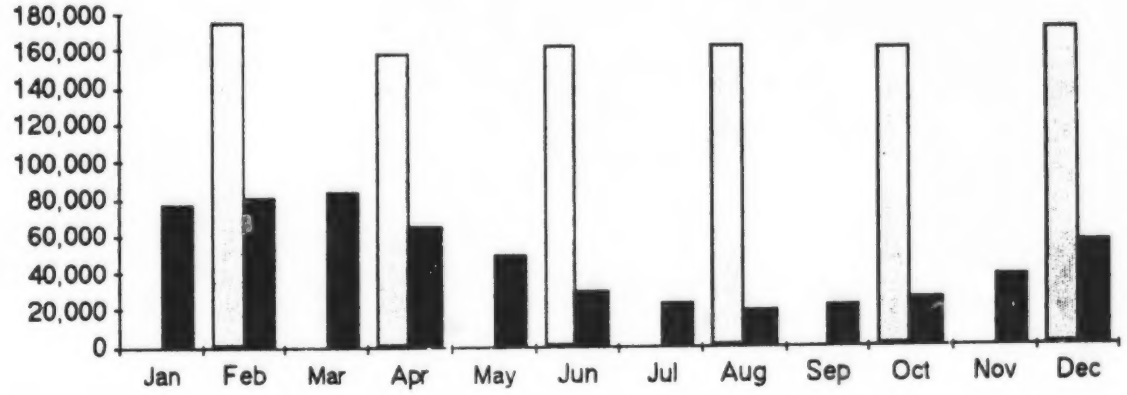
TABLE 1: Summary of Water and Energy Use

Month	Water	Kwh-Total	Energy GJ	Flow m3
1985				
January		70,000		
February	198,000	94,000		
March		80,000		
April	148,000	64,000		
May		54,000		
June	169,000	28,000		
July		28,000		
August	178,000	20,000		
September		22,000		
October	170,000	22,000		
November		38,000		
December	183,000	52,000		
Total 1985	1,046,000	572,000		
1986				
January		78,000		
February*	176,000	82,000	0.00	0
March		84,000		
April	158,000	66,000		
May		50,000		
June	162,000	30,000		
July		24,000		
August	163,000	20,000		
September		22,000		
October	161,000	26,000		
November		38,000		
December	171,000	56,000		
Total 1986	991,000	576,000		
	*** System commissioned 27 February 1986**			
1987				
January		72,000		
February	181,000	68,000		
March		80,000	46.30	
April	180,000	52,800	51.41	
May		47,200	58.79	
June	178,000	32,000		
July		24,000	70.05	1120.9
August	183,000	24,000	77.67	
September		20,000	82.59	
October	178,000	26,000	86.29	
November		40,000	88.98	
December	171,000	44,000	90.40	
Total 1987	1,071,000	530,000		
1988				
January		57,500	91.23	
February	173,000	83,500		1713.6
March		75,500	94.87	
Total 1988	173,000	216,500		

Water and Electricity Use in 1985



Water and Electricity Use in 1986



Water and Electricity Use in 1987

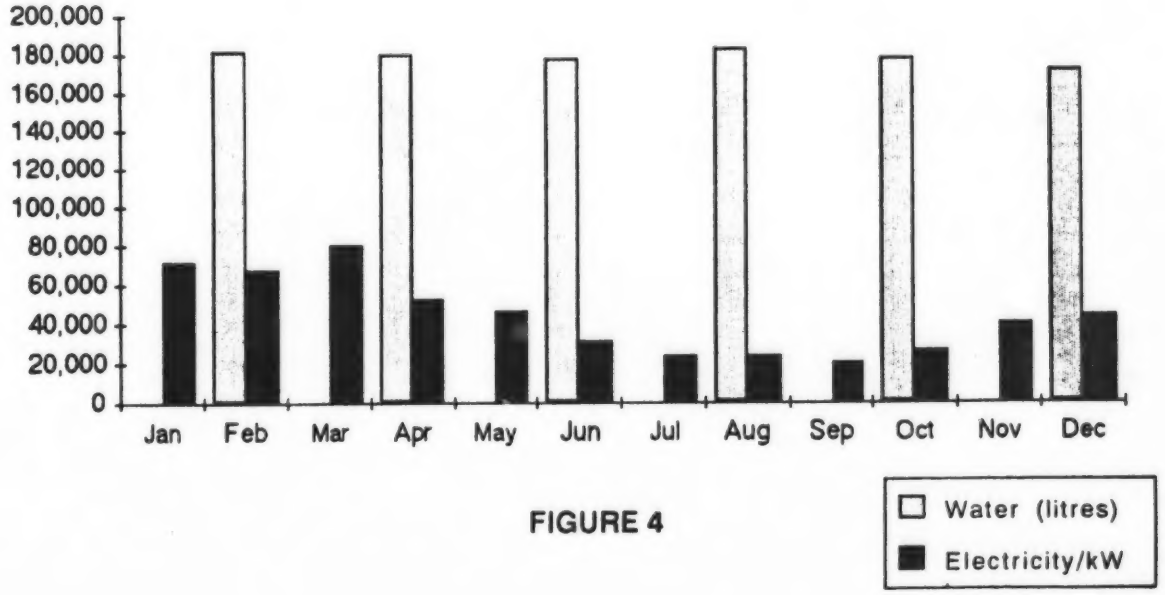


FIGURE 4

of total water usage. Further discussions with the Supervisor suggested this was reasonable i.e. 80% of the total water usage could be in the form of hot water.

The hot water load is about one-third what was predicted, so the energy produced can reasonably be expected to be less than the energy predicted; it was actually 49% in 1986 and 52% in 1987, consequently the savings have been half what was predicted. The usual method of evaluating solar system performance is in terms of GJ/m^2; this installation has produced 1.3 GJ/m^2 but should be more than 2.0 GJ/m^2 and even as high as 2.6 GJ/m^2. A higher hot water load would result in a higher energy output and, hence, higher GJ/m^2. With our experience since that installation and the improvement of the technology the installed cost could be lower and with a number of similar installations the costs could go down approximately 25%, i.e. from $17,300 to $12,500. The savings are 46 to 48 GJ per year, which means 12,000 to 14,000 kWh of electricity saved which represents $600 to $800 per year at present energy costs.

Conclusion

The hot water load which we predicted for the building was 2,660,000 litres/year. This was based on ASHRAE design figures which are generally conservative and designed to ensure that there is not a shortage of hot water. The total consumption of water, hot as well as cold, varied between 991,000 and 1,071,000 litres/year over the past three years, or about one million litres/year on average ± four percent. The measured flow through the solar storage tanks which represents the total hot water used in the building was 1,700,000 litres over the two years since February 1986 that the energy meter has been installed, which is an average of 856,000 litres/year. This was verified over a short period from June 1987 to March 1988 within four percent. Therefore, the hot water load at Craigwiel Gardens apartments is less than one-third what was predicted.

The energy load predicted by WATSUN was 94.5 GJ. The actual values from March 1986 to February 1987 was 46.30 GJ and March 1987 to February 1988 was 48.57 GJ. The system currently produces about 1.3 GJ/m^2 but, if optimized, should be producing at least 2.0 GJ/m^2 and could be up to 2.6 GJ/m^2. Therefore, the solar gain is about half what was predicted but is dependent on the hot water load which, as already discussed, was over- predicted.

The solar energy gain was about 47 GJ/year which represents savings of 13,100 kWh/year on the electrical hot water bill. At a cost of 5¢/kWh this solar gain represents a saving of $660 each year. Such a saving is modest at present, but will increase with more hot water demand. The present occupants do not use as much hot water as was expected; most of them grew up learning to be very conservative in energy use. Another generation in that same facility may use all the hot water the solar system can provide. Further, as electricity costs increase the savings become more significant. We plan to review the possibility of supplying hot water from Craigwiel Gardens to the Craigwiel Nursing Home which is adjacent. This could increase the yearly hot water load and increase the savings.